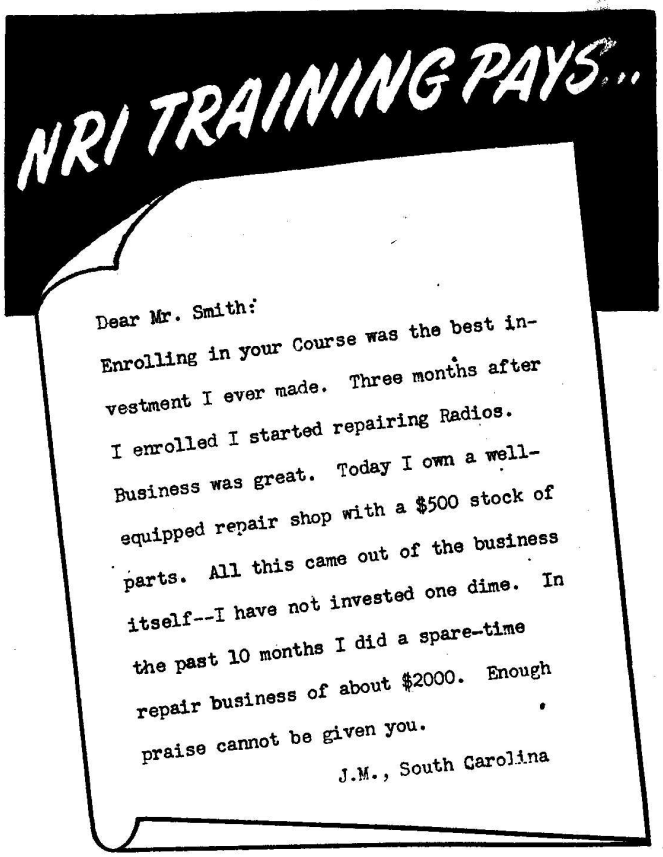
# How to Make Extra Money

# FIXING RADIOS

NATIONAL RADIO INSTITUTE, WASHINGTON, D.C.

## No. 10 How To Test and Repair Loudspeakers

## RADIO SERVICING METHODS



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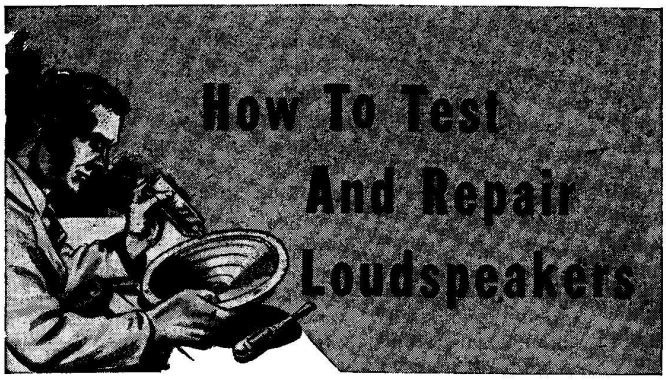



TO complete our study of the major parts in a radio receiver, we shall now discuss the loudspeaker—the device that translates electrical signals into air vibrations that we can hear.

Although you now have a general idea of how loudspeakers operate, you have not yet studied them in detail (this comes later in your Course). Therefore, we shall first give a *brief* description of the operation of a loudspeaker. Then, we shall take up loudspeaker troubles in order and explain how to check for and how to remedy each type of defect.

► A loudspeaker, whatever its type, has two basic parts —a *driving mechanism* and a *cone* or *diaphragm*. The driving mechanism converts audio signals into vibratory (back and forth) mechanical motions. The cone (or diaphragm) is secured to the driving mechanism and vibrates with it. The cone vibrations cause similar vibrations in the surrounding air; it is these latter that we hear as sound.

There are three types of loudspeakers in use today, but one, the magnetic speaker, is gradually disappearing. Therefore, we shall study first the two more common types, known respectively as electrodynamic and p.m. (permanent magnet) dynamic loudspeakers.

The driving mechanisms of these two speakers are similar. Each contains a source of magnetic flux that produces a fixed magnetic field. A small coil, mounted at the small end of the speaker cone, is positioned in this field. Since the audio signal from the receiver is fed to

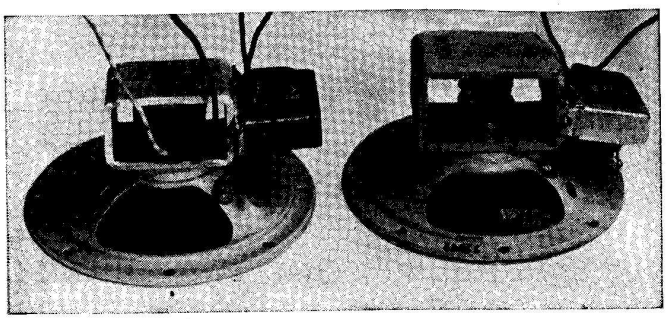
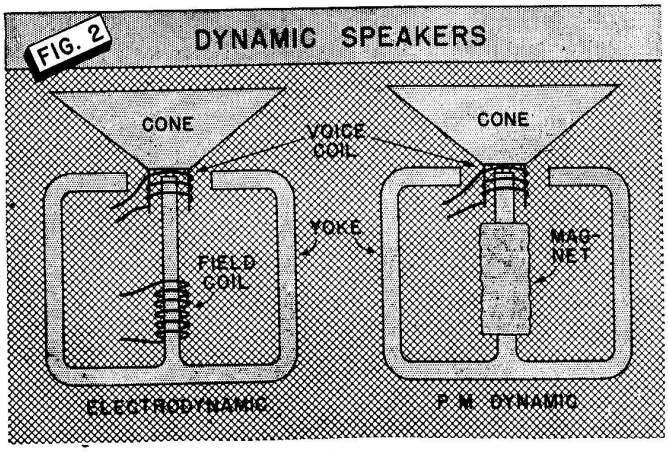


**FIG. 1. The two most common types of speakers: left, electrodynamic; right, p.m. dynamic.**

this coil, it is called the "voice" coil. When there is no current in the voice coil (that is, no audio signal from the receiver), it is motionless. However, when the receiver is tuned to a broadcast, current flows through the voice coil and produces a varying magnetic field in and around it. The interaction of the voice coil field and the fixed magnetic field causes motion of the voice coil, moving it in and out at a rate that corresponds to the frequency and shape of the audio signal. (This is a phenomenon you will study in detail in your Course.) This motion of the voice coil causes a similar motion of the cone and so produces sound.

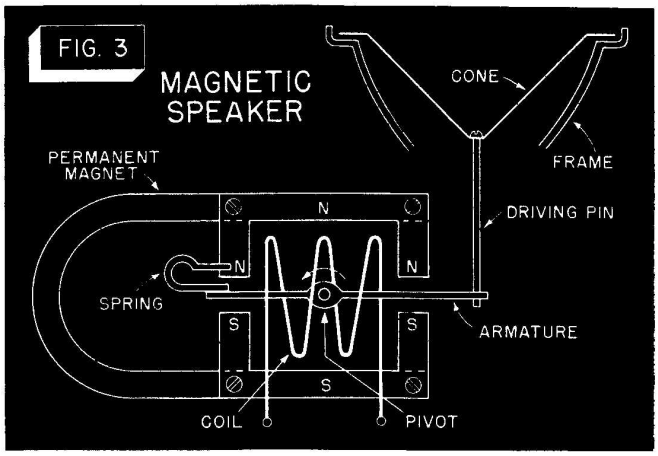
Both an electrodynamic and a p.m. dynamic loud-






speaker are shown in Fig. *1*. Their chief operating parts are shown in Fig. *2*. Notice—the only essential difference between them lies in the source of magnetic flux used to produce a fixed field. A powerful permanent magnet is used to produce the fixed field in a p.m. speaker. In an electrodynamic speaker, the fixed field is produced by a coil (called a "field coil") through which a d.c. current is passed.

This fixed field exists across an air gap between the central pole piece and the ends of the yoke or "pot." The voice coil, which is wound on a light fiber form, slips over the central pole piece and is held in the air gap by the paper cone and by a flexible support called a "spider." When it is properly positioned, the voice coil touches neither the central pole piece nor the ends of the yoke. The cone is secured at its outer edge to the speaker frame.




Because of the way they operate, both types of speakers are known as "dynamic" or "moving-coil" speakers. ► The magnetic speaker is shown in Fig. *3*. This speaker uses a horseshoe-shaped permanent magnet and a large coil wound around a pivoted armature. The changes in the flux produced by audio current variations in this coil cause the armature to swing back and forth around its pivot. This motion is transferred through a driving pin

to the cone apex, moving the cone in and out.

We will dismiss magnetic speakers now because they are becoming rather rare and, when defective, they are almost invariably replaced rather than repaired. Usually they are replaced by one of the small p.m. dynamic types. We will show you later how to order these replacements.

► On the other hand, electrodynamic and p.m. speakers are repaired rather than completely replaced in most cases. Usually only one part of a dynamic speaker becomes defective, and such a part can frequently be repaired or replaced without much difficulty.

Both these speakers have cone troubles, caused by natural aging of the cone, by rips and tears in the cone material, and by loosening of the cement that is used to hold the outside rim of the cone to the speaker frame. The spider, which is used to center the voice coil in the magnetic air gap sometimes warps or breaks.

In either speaker, the fixed magnetic field may be upset. In the electrodynamic, the field coil may open or short-circuit like other coils, and in the p.m. dynamic, the permanent magnet may weaken.

Now, let's see how to test for and repair these various speaker defects.

## TESTING AND REPAIRING FIELD COILS

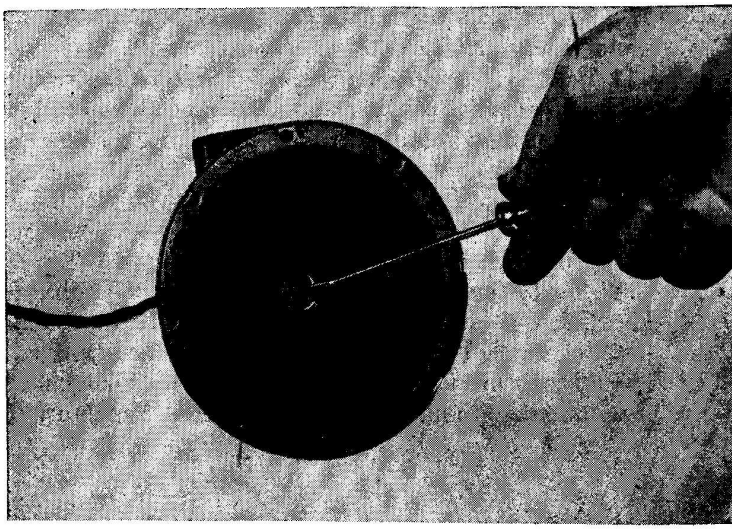
The most usual field coil trouble is an open coil, although shorted turns sometimes occur. If you suspect that the field is open, you can check it easily by holding a screwdriver or other iron tool near the center pole piece (Fig. 4) while the receiver is turned on. If magnetism is present, as it should be if current is flowing through the field coil, the screwdriver will be strongly attracted, and you will have to exert appreciable force to pull it away. If the field coil is open, or if energizing current is not flowing because of some other defect, there will be either no pull or only a slight pull caused by residual magnetism.

This test will magnetize your screwdriver, and you will find that for quite some time it will pick up bits of iron and steel. A magnetized screwdriver is often useful. However, it is also annoying sometimes—when you are trying to start a screw through an iron washer in an inaccessible hole, for example—so don't magnetize all your screwdrivers. The magnetism will disappear with time, or you can remove it by rapping the screwdriver across the edge of your workbench.

► You can also check the field winding with your ohmmeter. Place the ohmmeter test probes on the terminals of the field, after disconnecting the field from the set to avoid shunt paths. No reading indicates that the field coil is open.

***Shorted Turns.*** When the turns on a field winding are shorted, the inductance is reduced, as with any other coil. An ohmmeter test is of value only if you know just what the field resistance should be. However, even when the field resistance value is given, it may be the "hot" resistance—the value reached after the set has warmed up. Since shorted turns cause excessive heating, the measured resistance may not be very different from normal. When you have had enough experience, you can judge from the heat of the field and from the receiver operation whether shorted turns are a possibility. Even so, you must make a check to see that the overheating is not caused by a short elsewhere in the set, and you should remember that speaker fields

**FIG. 4. How to test the magnetic pull of an electrodynamic speaker with a screwdriver.**



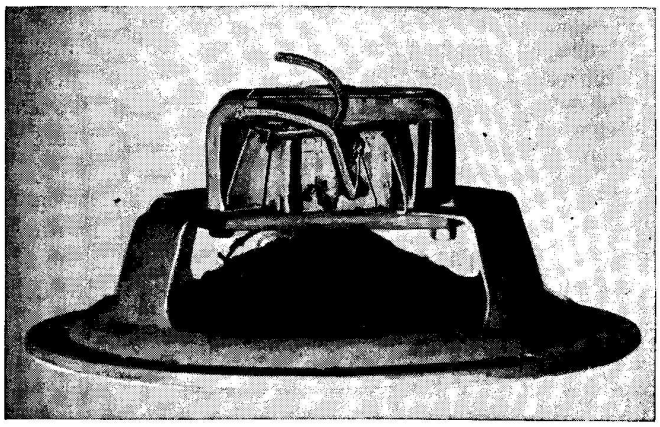


**FIG. 5. Cut away the insulation like this when you are looking for a field-coil break. Be careful not to cut the coil wire.**

become somewhat warm even under normal conditions.

***Repairing the Field Winding.*** Short-circuited coils cannot be repaired; a new field is necessary. However, when a field coil *opens,* it is always worth while to see if repairs can be made. Carefully cut through the insulating paper wrapped around the field so that the field leads are exposed as shown in Fig. *5.* Often you will find the break near the point where the field leads join the external leads. If you can see the break, use fine sandpaper or emery cloth to clean the insulating enamel off the broken wire and then resolder the connection. If necessary, splice on an extra length of wire to complete the circuit.

***What To Do When the Field Coil Is Defective.*** When you cannot repair a speaker field coil, you can do one of the following things:

1. Install a new field yourself.
2. Have one installed through or by your local parts jobber.
3. Install a new loudspeaker.

To make the repairs yourself, you must be able to get the old field out of the yoke or "pot." If the yoke is held together by bolts, this will not be difficult. But if special tools are needed to remove the center pole piece, it will be best to have your local parts jobber do it.



If you can get the old field out, simply reverse the procedure to install a new one. Of course, you must use a suitable replacement. The new field must have the same physical dimensions as the old and, also, approximately the same resistance. The best way to insure a good fit is to give your supplier the make and the model number of the receiver and the speaker part number. Sometimes different speakers are used with the same model receiver when this model is used in several different cabinets. In such a case, if you cannot give the speaker number, usually the cone diameter will identify the speaker. This is the *outside* diameter of the cone, measured across the face of the speaker.

If you find it difficult to get the old field out and cannot obtain a new field locally, it is worth while to take or send the entire speaker to your parts jobber or supply house. In either case the speaker will come back to you completely repaired and "ready to go" in about the same length of time it would take you to secure a replacement field. The cost of such professional service is usually less than your labor cost, and the time saved will really save you money if you are charging properly for your service time.

Then, too, you may find that the magnetic circuit is welded together and cannot be disassembled in an ordinary service shop. In this case a new speaker is necessary. Many of the larger manufacturers such as Philco and General Electric, who make speakers of this type, have an exchange service. The old loudspeaker is returned to them through their nearest local distributor for a new one.

In some cases, your customer may not wish to wait for such an exchange to go through. If so, you can simply discard the old loudspeaker and buy another.

## P.M. SPEAKER FIELD TROUBLES

About the only trouble you will encounter in the magnetic circuit used in a p.m. speaker is a loss of magnetism through age or through the fact that someone has disassembled the yoke or magnetic circuit. (Never take apart the yoke or pot assembly of a p.m. speaker; the magnet may lose so much magnetism that it will be

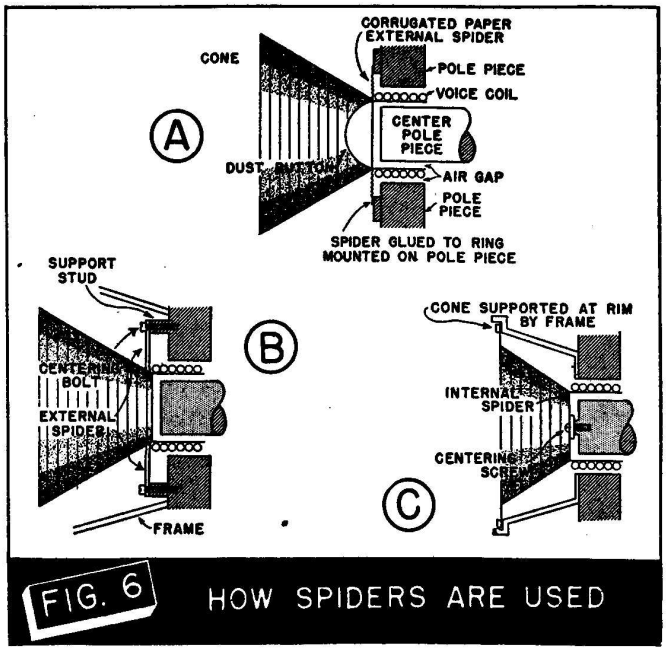



FIG. 6 HOW SPIDERS ARE USED

worthless.) There is no easy test for this except for the peculiarly distorted operation of the receiver, about which you will learn. The screwdriver test is no good until the field is extremely weak, and you will usually be called in long before this.

There is no way for you to remagnetize a p.m. speaker in your shop. If the speaker is an expensive one, have the job done by either the manufacturer or some firm specializing in loudspeaker work. Your local parts distributor will be glad to send the speaker off for you and to notify you when it is returned. If the speaker is inexpensive, it may be better to buy a new one.

## CONE AND VOICE COIL DEFECTS

Speaker field defects are not the only source of trouble. In fact, there is more likelihood that something will be wrong with the cone, the voice coil, or the adjustment of the voice coil.

The voice coil must move freely to follow the signal variations. Hence, there are centering supports or

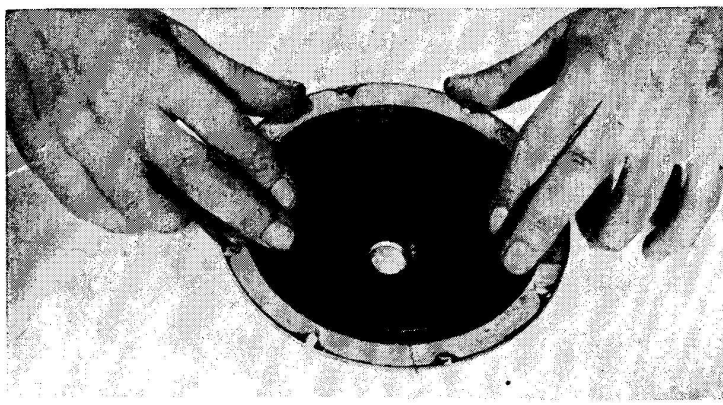


spiders designed to hold the voice coil in the center of the air gap between the pole pieces. These spiders must not hinder cone movement any more than is necessary, so they are made of flexible paper or fiber and are fashioned to permit the desired movement. (They are called "spiders" because the early types all had long "legs".) Three types of spiders are shown in Fig. *6*. The corrugated paper external spider in Fig. *6A* is the type most widely used at present. The cone suspension methods shown in Fig. *6B* and Fig. *6C* were employed in older loudspeakers, but you'll find plenty of them requiring service.

► Normally, corrugated paper spiders like those shown in Fig. *6A* will not cause trouble once they are properly installed. Of course, even with this type, the cone may tilt if the cone warps or the frame becomes bent. This will throw the voice coil to one side and allow it to strike the pole pieces as it moves back and forth. This can be corrected by bending the frame that supports the cone to correct for the warpage, and re-centering the voice coil. You must experiment to learn just how to bend the frame. If bending it in one direction makes the trouble worse, bend it in the opposite direction.

One of the tests you can use to determine when a cone is properly centered is shown in Fig. *7*. *With the set turned off*, press evenly on the outside edges of the cone with your fingers. Listen carefully to the speaker. You can hear the voice coil scraping against the pole piece if the room is quiet, and you can sometimes even feel

**FIG. 7. How to test a cone for proper centering. Be careful to push gently, so as not to damage the cone.**

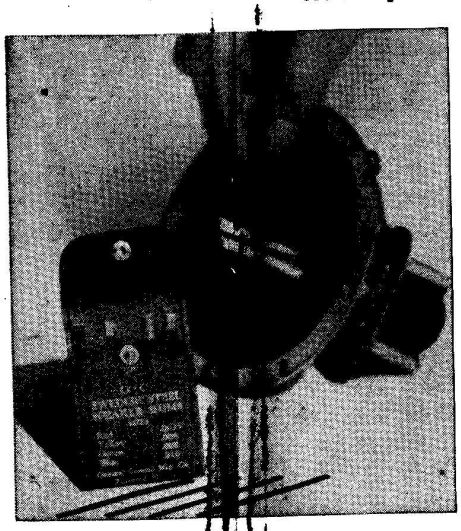


the obstruction as the voice coil strikes a pole piece. ► In the spider system shown in Fig. *6B*, one of the centering bolts holding the spider in place may loosen, allowing the voice coil to hit the pole pieces. In the system shown in Fig. *6C*, there is but one bolt; if it loosens, the voice coil may readily shift in position. In either of these cases, loosen all bolts holding the spider. Then push centering shims down between the voice coil and the center pole piece as shown in Fig. *8*. These shims (which you can buy for a few cents from any radio supply house) will properly center the voice coil and will hold it in the required position while you tighten the adjusting screws. In the system shown in Fig. *6B*, the cone is in such a position that an end wrench is the best tool to use when working on the bolts, for there isn't room to get at them with a screwdriver.

When you do not have shims available, it is possible to center the voice coil by working on the cone in the manner shown in Fig. *7*. That is, apply differing pressures until you find the position where the voice coil will move up and down without rubbing, then hold the cone while the bolts are tightened. Usually, however, this is rather difficult to do when working on the system shown in Fig. *6B*. The cone is likely to shift when you move the speaker to tighten the bolts.

***How To Clean the Air Gap.*** The same effect as an off-center voice coil will be produced if dirt or metallic particles get into the air gap. With the modern corrugated external spider and dust button shown in Fig. *6A* there is little danger of this happening, for everything is sealed up. However, with the spider arrangements shown in Figs. *6B* and *6C*, it is quite a common occurrence for dirt and metallic particles to work their way into the air gap.

► Incidentally, if you ever work on a receiver that is part of a phonograph



Courtesy General Cement Mfg. Co.

**FIG. 8. How to center the voice coil with centering shims.**



combination and hear an odd buzzing noise from the speaker when it is producing bass notes, examine the speaker carefully for phonograph needles. These needles are attracted by the magnetism and will hang so that they vibrate against the cone.

Ordinary dirt may be removed by turning the speaker face down on the workbench and *lightly* tapping the back of the speaker while a program is coming in. (Don't hammer on a p.m. speaker and don't hammer *hard* on any kind.) Shaking or jarring the speaker this way will cause the dirt particles to work themselves out of the air gap and fall on the bench.

Iron filings and other magnetic particles are not so easy to remove, since the magnetism holds them in place. This is true even when the field is cut off, for there is a certain amount of residual magnetism present at all times.

The residual magnetism must be removed before these particles will fall out. The only simple way of doing this with an electrodynamic speaker is to apply an a.c. voltage to the field coil. First, disconnect the speaker field from its receiver connections (naturally, the receiver must be turned off), and then connect the field directly across the 110-volt a.c. power line and rap on the yoke. When the a.c. is applied to the field, the field is completely demagnetized twice each cycle. Your rapping on the yoke will make the metal particles slip slightly each time the magnetism is removed, and eventually they will fall out.

If the dirt or metal particles prove stubborn, it may be necessary to remove the cone and the voice coil altogether to clean out the air gap. (This is necessary anyway in a p.m. dynamic, since there is no way of removing magnetism.) However, whether this step is practical or not will depend on the ease of removing the cone, which we shall discuss later.

If you can get the cone and voice coil out, then you can use a pipe cleaner, obtainable from any tobacco store, to clean

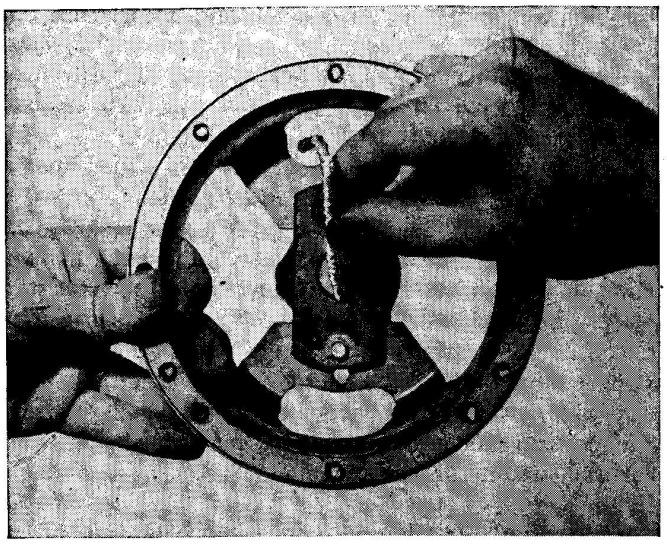


**FIG. 9. How to clean the air gap with a pipe cleaner.**

the air gap. All you need do is run the pipe cleaner around in the air gap (as shown in Fig. *9*), and it will remove the dirt and filings. After the gap is thoroughly cleaned, replace the cone and voice coil or install a new assembly.

► Loose turns on the voice coil will often produce the same effect as an off-center voice coil or dust in the air gap. Suspect this if you find that you cannot re-center a voice coil and apparently there is nothing foreign in the air gap. If it is easy to remove the cone, you may find it practical to take the cone out, cement the voice coil turns, and reinstall the cone. However, it is usually far better to replace the cone-voice coil assembly. We'll explain how shortly.

► Sometimes a crack in the spider will cause another kind of rattling noise. You can check for a cracked spider by moving the cone in and out with your fingers just as though you were checking for an off-center voice coil. You will find that a broken spider will come apart when you move it in this manner. This trouble is normally experienced only with the spiders made of fiber, in the styles shown in Figs. *6B* and *6C*.



## CONE TROUBLES

Loudspeaker cones are made in two ways. Some are pressed or molded of paper-like material. Others are rolled into shape and then glued along a seam running from the voice coil end to the outer edge of the cone. In either case, the outside flexible rim of the cone is glued to the frame, and the cone and voice coil are glued together. When a corrugated paper external spider is used, the outside rim of the spider is glued to a ring mounted on the pole piece.

Thus, loudspeakers depend on glue to a considerable extent. However, they work in closed compartments and often become quite hot. The heat may dry out the glue and permit some seam to open.

Much depends on just which seam opens as to the exact effect produced. In all cases except when the cone becomes unglued from the voice coil, the speaker will still work, but there will be distortion accompanied by a rattling noise. Once you have heard it, you can always recognize this trouble. The effect is like that produced by humming on a comb through a piece of paper.

To check a cone to see if it has become unglued, apply a gentle pressure to see if you can open the seam or joint that you suspect. Thus, if you push on the inside of the cone, moving it away from the frame, you can determine whether it has become unglued at the rim. Try on several sides, since the cone may have become unglued over just a small portion of the circumference, although often it becomes unglued all the way around.

An open seam or a loose edge can be quickly corrected by the use of speaker cement, applied under the cone rim or inside the seam. Wait long enough for the cement to dry and then try the speaker again. (All radio supply houses carry a suitable cement.)

Regluing the voice coil to the cone is somewhat more difficult. The same cement is used, but you must be sure not to get it down in the air gap. Sometimes it is necessary to take out the cone to reglue it. In these cases, if the cone is difficult to get out, it may be more practical to replace the cone.

Rips and tears in cones will also cause trouble. The

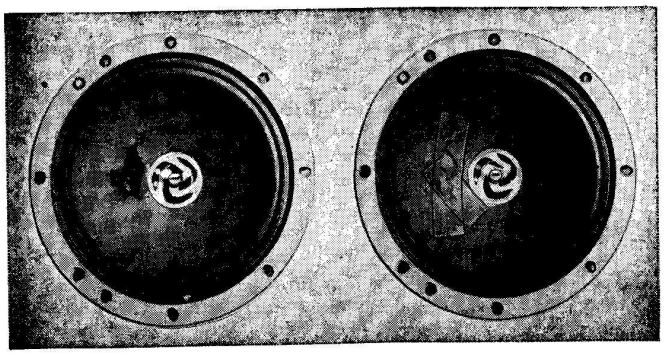


**FIG. 10. How to repair a torn cone with Scotch tape. Be sure the tape covers all parts of the tear. If the tear is large, it is a good idea to apply Scotch tape to the back as well.**

easiest way to repair a torn cone is to use Scotch tape, as shown in Fig. *10*.

► Any repair of the cone will change the weight of the cone somewhat. Naturally, this is bound to affect the tone quality, although often the difference will not be very noticeable.

If the cone is quite old, then usually it will have changed in weight anyway. Dust or moisture absorption will add to the weight of the cone, while a cone that has dried out may be lighter than normal.

In any event, since cones age, it is frequently more desirable to replace the cone than to repair it. In some instances it is even possible to improve the response of the loudspeaker because newer cones are made of better materials than some of the older types.

***How To Replace a Speaker Cone.*** The first step in this procedure is to make a careful examination to see if it is easy to replace the cone.

The kind with the corrugated paper spider, shown in Fig. *6A*, is not always so simple to replace. The spider and the cone rim are both glued in and are positioned so that the voice coil is properly centered. The replacement must be similarly installed, and calls for some skill. Some of these cones come in units with the spider and the voice coil already assembled. This assembly is installed first, then the cone is glued to the voice coil and to the speaker frame.



If it appears that replacing the cone will be a difficult job, then it is better to send the cone to a firm specializing in this or to have your local jobber send it away for you. In either case, you will receive the loudspeaker with the best possible cone installed in it in a professional manner.

► However, if you decide to do the work yourself, you must give your supplier the make and the model number of the receiver. If the model is not listed, it is advisable to turn in the old cone to your supplier so that he can duplicate it.

Unless you intend to send the old cone in as a sample, you can simply cut it out with a knife, after cutting or unsoldering the voice coil leads from their mounting brackets. After lifting the cone out of the way, you can then remove the paper and glue from around the edge, using a special cement solvent designed for this purpose. Sometimes the cardboard spacing rings around the edge of the old cone must be used again on the replacement, so don't destroy these until you see whether they are needed.

When installing the new cone, be sure to place it so that the voice coil leads will reach the point to which they should be soldered. If there are holes around the rim of the speaker for mounting purposes, and the cone has similar holes, be sure to position the cone so that the holes match. If the cone has no holes, and some are needed for mounting the speaker, make them by punching through the paper after the cone has been fastened in place.

Examine the cone, while holding it in position, to see if you can reach the voice coil leads easily. If it is going to be difficult to reach them and hold them in position with the cone properly in place, then you had better solder them first. However, if it will be easy to solder later, mount the cone first, if you wish.

The next steps depend on the instructions you obtain with the replacement cone. If there is anything unusual about the installations, an instruction slip will usually be found packed with the cone. Sometimes the voice coil should be centered and the spider fastened before the

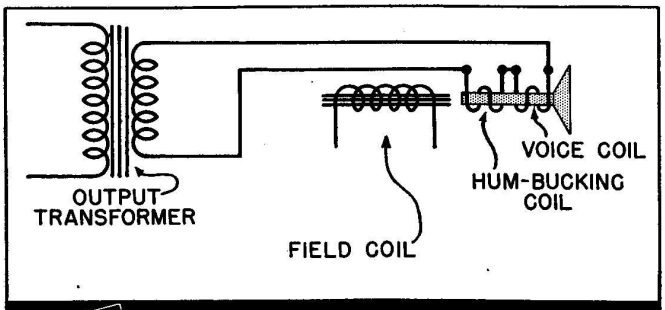



FIG. 11 HOW A HUM-BUCKING COIL IS CONNECTED

cone is glued in the rim; sometimes the cone should be glued in first. When in doubt, follow the first procedure. Otherwise, if you glue the cone at the outer edge first, you may throw the voice coil into a position where the spider cannot center it. Of course, while the cement is still wet, you can move the cone into position for greatest voice coil freedom. When the cement has dried, the speaker is ready to be tried out.

## HUM-BUCKING COILS

A certain amount of alternating current, in addition to the required d.c., flows through an electrodynamic speaker field in most receivers. This varying current will cause the magnetism produced by the field to vary in strength. As a result, a hum voltage may be induced in the voice coil which will cause it to move in and out as the field strength changes, producing hum.

This effect is reduced in some speakers by what is known as a hum-bucking coil. The hum-bucking coil is wound around the central pole piece (next to the field coil) and may consist of five to ten turns of insulated wire. It is electrically separate from the field, but it is connected in series with the voice coil as shown in Fig. *11*. If the strength of the field varies, hum voltage will be induced in the hum-bucking coil as well as in the voice coil. These two induced voltages are equal and, if the proper connections are made to the hum-bucking coil, their polarities will be opposite. Therefore, they will



cancel each other, and no hum current will flow through the voice coil.

Whenever it is necessary to wire the voice coil circuit of a speaker using a hum-bucking coil (as may be the case when you are replacing the cone), excessive hum will be encountered if the proper connections are not made. If you do find hum, try reversing the voice coil connections to the hum-bucking coil. If the hum increases, the original connections were right; if it decreases, the original connections were wrong.

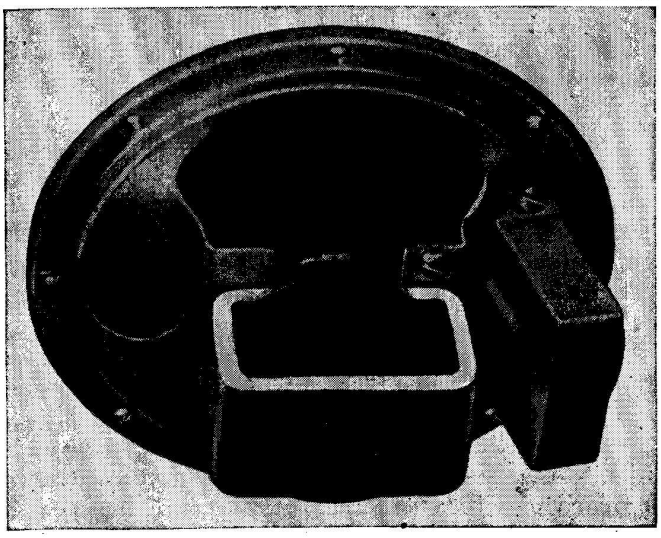
## OUTPUT TRANSFORMER TROUBLES

We have already discussed output transformers when we were discussing coils and transformers. However, the output transformer is actually a part of the loudspeaker system and is very frequently mounted on the loudspeaker frame, as shown in Fig. *12*. Now that you know more about speakers, there are a few additional hints we may give here.

The most usual trouble with an output transformer is an open primary, which you can easily discover by

**FIG. 12. In this speaker, the output transformer is mounted on the frame (at right of field coil).**

Courtesy Jensen Radio Mfg. Co.



checking for continuity with your ohmmeter. An exact duplicate output transformer is available if the receiver is a well-known make. However, if you cannot find a duplicate, you may use a universal type.

When unsoldering the voice coil leads and resoldering the new leads, be careful not to allow excess solder to drip down inside the cone assembly.

If the original output transformer was mounted on the speaker frame, you may find that the replacement does not fit the same mounting holes. In some instances, a supporting bracket may have to be installed. It is not desirable to drill holes in the speaker frame for mounting the new transformer, because the drill shavings are metal and may get down in the voice coil gap where they will be very hard to remove. Be careful also in removing rivets, nuts, and bolts—be sure that you keep such objects out of the air gap.

## ORDERING NEW LOUDSPEAKERS

There will be times when it is desirable to order an entire new speaker rather than to have an old one repaired; you may have a speaker that is not worth repairing, or you may want to replace a magnetic speaker with one of the p.m. dynamic types. (A magnetic speaker is seldom replaced by an *electrodynamic* speaker, because, to do so, it would be necessary to rewire the receiver to provide voltage for the field coil. A p.m. speaker requires no such circuit revision.)

Many servicemen replace the entire speaker when the field coil is burned out, since the old cone probably should be replaced anyway, and very frequently it is necessary to destroy the cone to get the defective field out. In such instances, time will be saved if an exact duplicate speaker is available, even if no exchange policy is followed by the manufacturer of the set.

When you buy a replacement speaker and no exact duplicate is available, you must consider the physical size of the original speaker. In particular, the outside diameter of the cone must be the same size as the original. This is necessary so that the replacement will fit properly over the opening in the cabinet. If the speaker



is mounted on the receiver chassis, as it is in a midget receiver, then the depth of the speaker and the position of the mounting holes may also be important. In these cases it is best to take the original speaker to your supplier so that he can duplicate it.

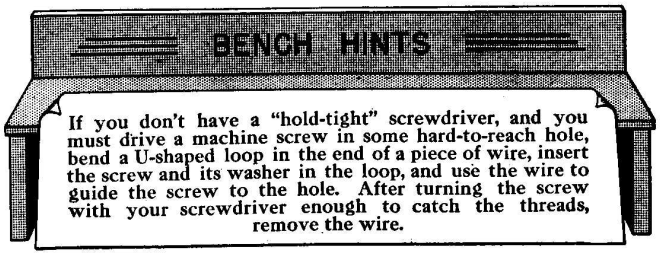
If the original speaker is an electrodynamic type, you will have to obtain a replacement speaker with a field resistance like that of the original. You will have to determine the field resistance from the manufacturer's data on the set or by measuring the resistance of the old field if it is still good.

► To use the same output transformer, the replacement speaker should also have the same voice-coil impedance. Unfortunately, it is rare to find the old voice-coil value given, although that of the replacement will be known. (You will learn more about this problem of impedance matching in your Lessons in Radio Fundamentals.) Therefore, since the output transformer is usually on the speaker, it is good practice to replace it along with the defective speaker. If you can give your supplier the types and number of power output tubes used in the radio, he will be able to supply you with the proper output transformer for the speaker you are purchasing.

When you replace a magnetic speaker with a p.m. dynamic, be sure you get an output transformer designed to operate with the dynamic speaker.

## GETTING PRACTICAL EXPERIENCE

A number of the steps mentioned in this and in other RSM Booklets are rather easy to try out and will give you valuable practical experience. For example, the first time you service a receiver using an electrodynamic



speaker, make the screwdriver test for magnetism. First, repair the set. Then, with the receiver turned on, hold a screwdriver blade near the center pole piece and note the strong pull. Next, turn the receiver off and feel how the strong pull has disappeared. This effect will be the same as that encountered when the field coil is open or when some other receiver defect prevents current from flowing through the field coil. You will thus learn how to detect low magnetism by the screwdriver pull.

► For more experience, listen to the distortion that occurs when there is an off-center voice coil. The next time you see a speaker that has an internal-type spider like that shown in Fig. *6C*, deliberately throw the cone off-center. Loosen the centering screw and push down on one side of the cone edge so that the voice coil will be moved to one side, then tighten the centering screw. Now move the outer edge of the cone up and down with your finger tips to feel the voice coil rubbing against the pole pieces and listen to the scraping sound. Then, turn on the receiver and listen to both music and voice reproduction. You will find that low-frequency notes are affected far more than high-frequency notes because there is greater movement of the cone at low frequencies. This will cause men's voices to be distorted more than women's voices. Some musical tones will be quite distorted, but high-frequency musical tones will come through fairly well. Once you have familiarized yourself with the sound of an off-center voice coil, then recenter the voice coil in the manner we have described. Often, you won't have to use shims at all, because the spider will cause the voice coil to spring right back in place as soon as the centering screw is loosened.

► It is also a good idea to get some practice in installing cones, if you intend to do this work yourself and not have it done for you. One way to do this is to obtain one or two junked speakers from some local radio man and obtain new cones for them. Of course, it is preferable to obtain speakers taken from well-known receivers, so that replacement cones will be available.